Abstract

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This work compares and assesses the effectiveness of beta backscatter (BB) and x-ray fluorescence (XRF) for measuring the thickness of gold coatings on two substrates: silicon and an iron-nickel alloy. A set on samples of known gold coating thickness was measured in each case. The BB method is used to count the number of electrons (beta particles from a very small radioactive source) backscattered from a sample. This data was recorded in Excel and plot using Igor. The XRF method uses x-rays generated in the sample from a primary x-ray beam of higher energy. The spectrum of the outgoing x-rays is collected and all the peaks in that spectrum are identified. The peak intensities for the primary peaks of each element can be quantified, the data summarized in Excel, and the data plot in IGOR. Both methods are capable of measuring coating thickness, BB is simple and easy to use but the compositions of both the coating and substrate must be a known and standards are required in order for calibration. Although we used standards with XRF in this work, there is software that can be used for standardless XRF thickness measurements if the composition of all of the layers and the substrate is known. Although both techniques worked for these systems, if the coating were much thicker only BB would be applicable because it is capable of using higher energy isotopic sources. XRF is limited by the characteristic x-rays from each element.

Comparison of Beta Backscatter and X-ray Fluorescence Methods to Measure Coating Thickness

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Objectives

Beta backscatter (BB) and X-ray fluorescence (XRF) can both be used to measure coating thickness nondestructively. This work compares and assesses the two techniques for two sets of known thickness samples, which can be used for calibration.

Background

Why is it important to know the coating thickness?

For a given application, there is usually either a minimum or optimal range of coating (e.g. paint or, in our case, gold plating) thickness that performs best. When coated items are fabricated or purchased it is necessary to confirm whether or not the coating meets requirements.

Why gold?

Gold is commonly used because it is non-reactive and a good conductor.

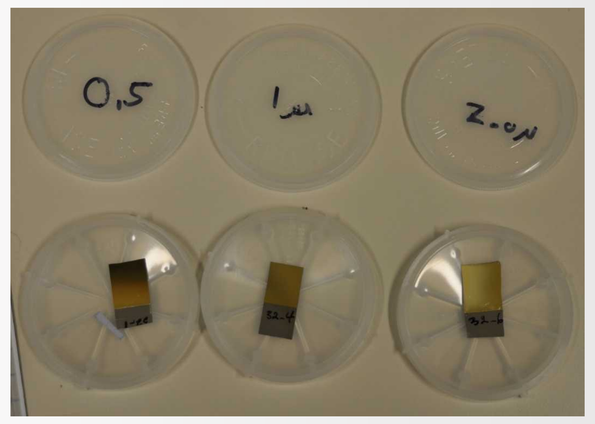


Figure 1: Au on Si samples.

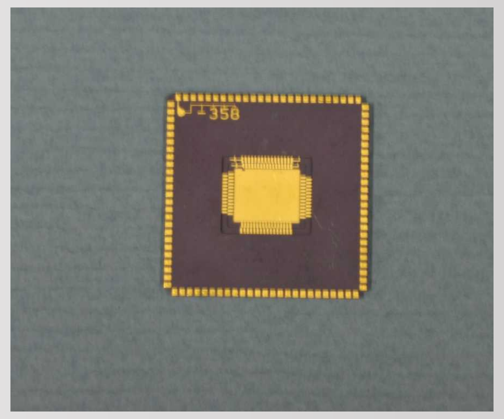


Figure 2: Gold plated part for use in microcircuitry.

Methods

In BB electrons from a radioactive source (i.e. beta particles) bombard a surface and are counted as they are scattered (backscattered) into a detector behind the source. Higher average atomic number (Z) materials backscatter more. For a known coating on a known substrate of lower Z, thicker coatings result in higher count rates.

In XRF a primary beam from an x-ray tube creates a hole (absence of an electron) in cores of atoms . These atoms decay by emitting x-rays that are characteristic of each element. For a coating thin enough, the substrate characteristic x-rays will penetrate the coating to appear in the x-ray spectrum in addition to the coating element(s).

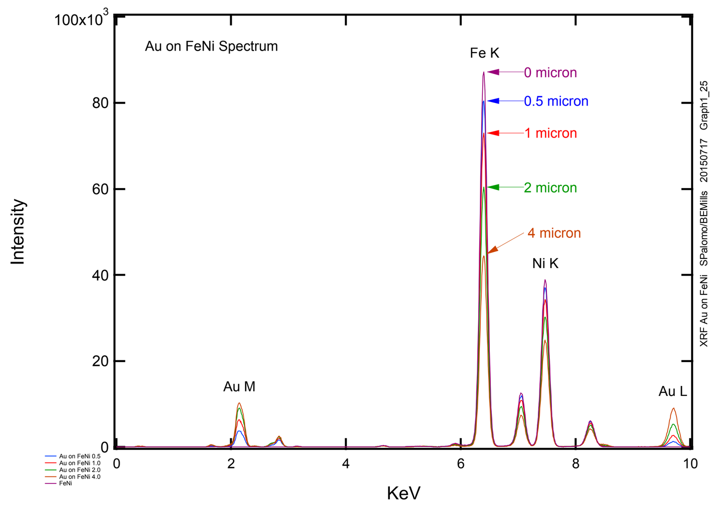
Results

-Two sets of gold plated samples, Au on Fe-Ni and Au on Si, were tested using both methods.

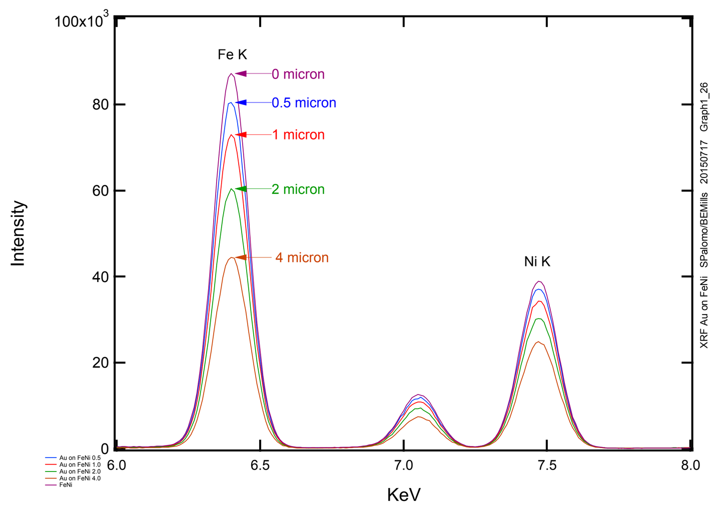
-XRF is able to identify elements within the sample to confirm the composition. Note that the Au on Si samples have a Ni adhesion layer under the gold.

-BB, a simpler approach, can be used with different isotopes to measure different thickness ranges. Higher isotope energies can measure thicker coatings. Lower energies give finer resolution for thinner coatings. Three energies were measured using BB. Only the optimal isotope results are shown.

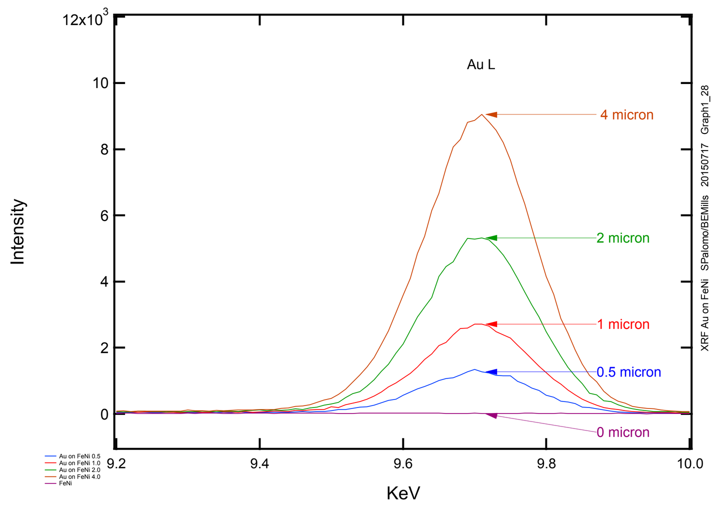
Au on Fe-Ni



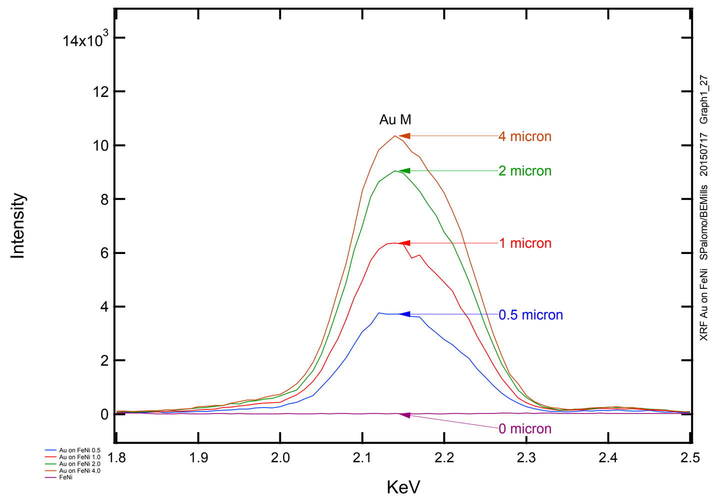
Spectra of standards in the energy range of all relevant x-ray peaks.



The intensities of the iron and nickel peaks decrease with thicker gold since some the x-rays are absorbed as they penetrate the gold layer.

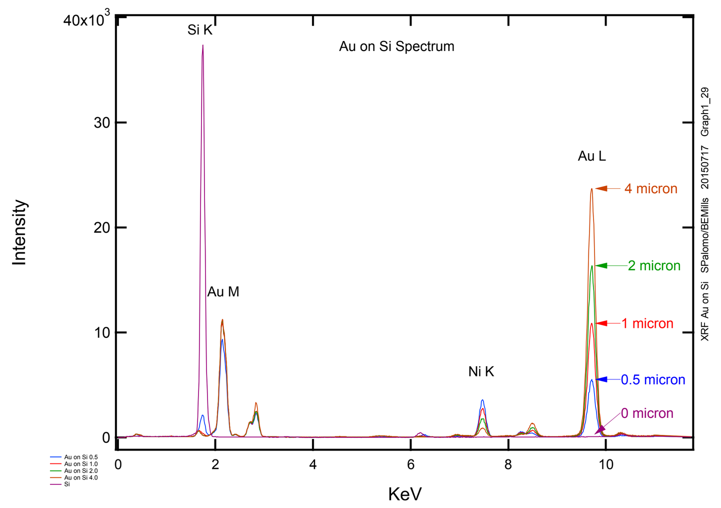


Au L intensity increases with increasing coating thickness.

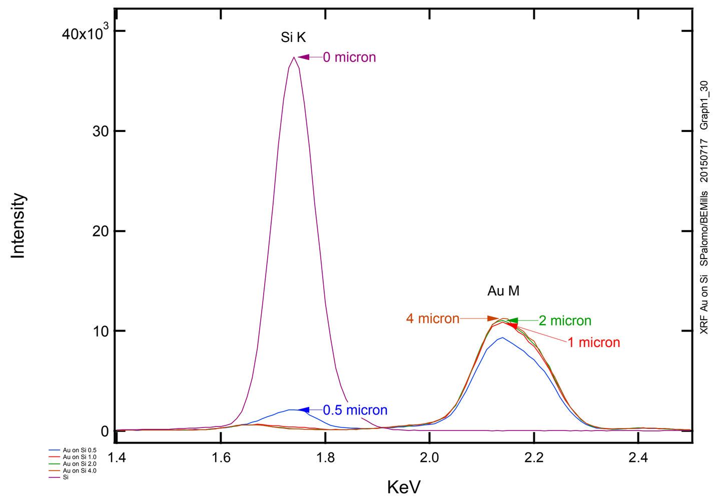


Au M intensity changes at a different rate because of greater self absorption at the lower x-ray energy.

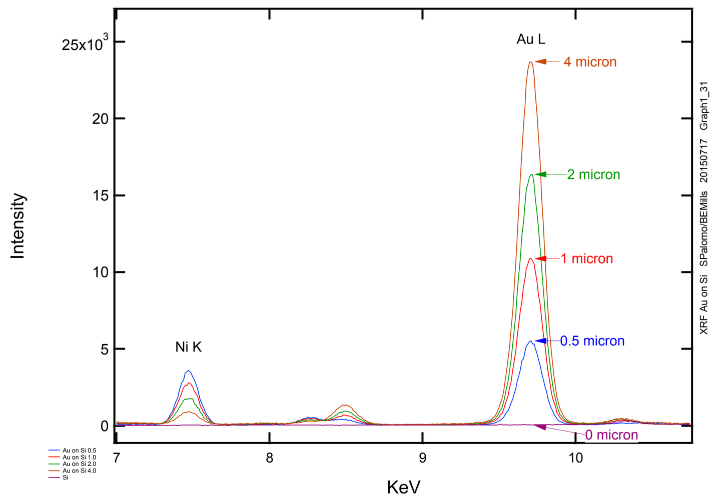
Au on SI



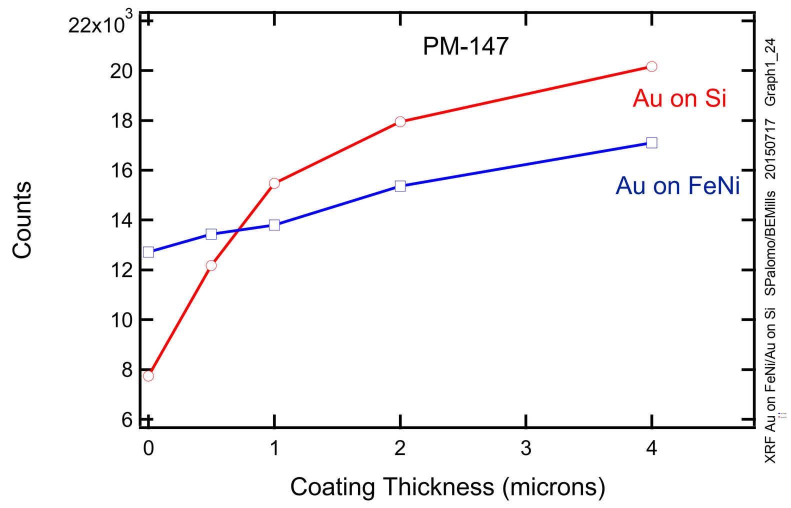
Spectra of standards in the energy range of all relevant x-ray peaks.



Since Si K has a lower energy than Fe or Ni, the thicker the Au coating the more x-rays are absorbed while passing through the Au layer.



The Ni K intensity decreases as the Au thickness increases but is absent in the 0 micron spectrum, indicating that Ni is used as an adhesion layer between Au and Si.



Radiation source PM-147 was found to have the optimal energy for these samples. Calibration graph for both sets of samples is shown.

Discussion

Comparisons

BB	XRF
-Simple -Quick -Different isotopes permit measurement of more thickness ranges	-Gives intensities for each element in coating and substrate that can be seen. -Longer to interpret results -May find the unexpected

Conclusions

Both methods can be used to measure coating thickness, depending on the system (coating/substrate/thickness combination). BB is simple to use and relatively inexpensive but requires standards. Although we used standards with XRF in this work, there is software that can be used for standardless XRF thickness measurements if the composition of all of the layers and the substrate is known. This can be a subject of future work.

Thicker coatings may require BB with a higher energy isotope.

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